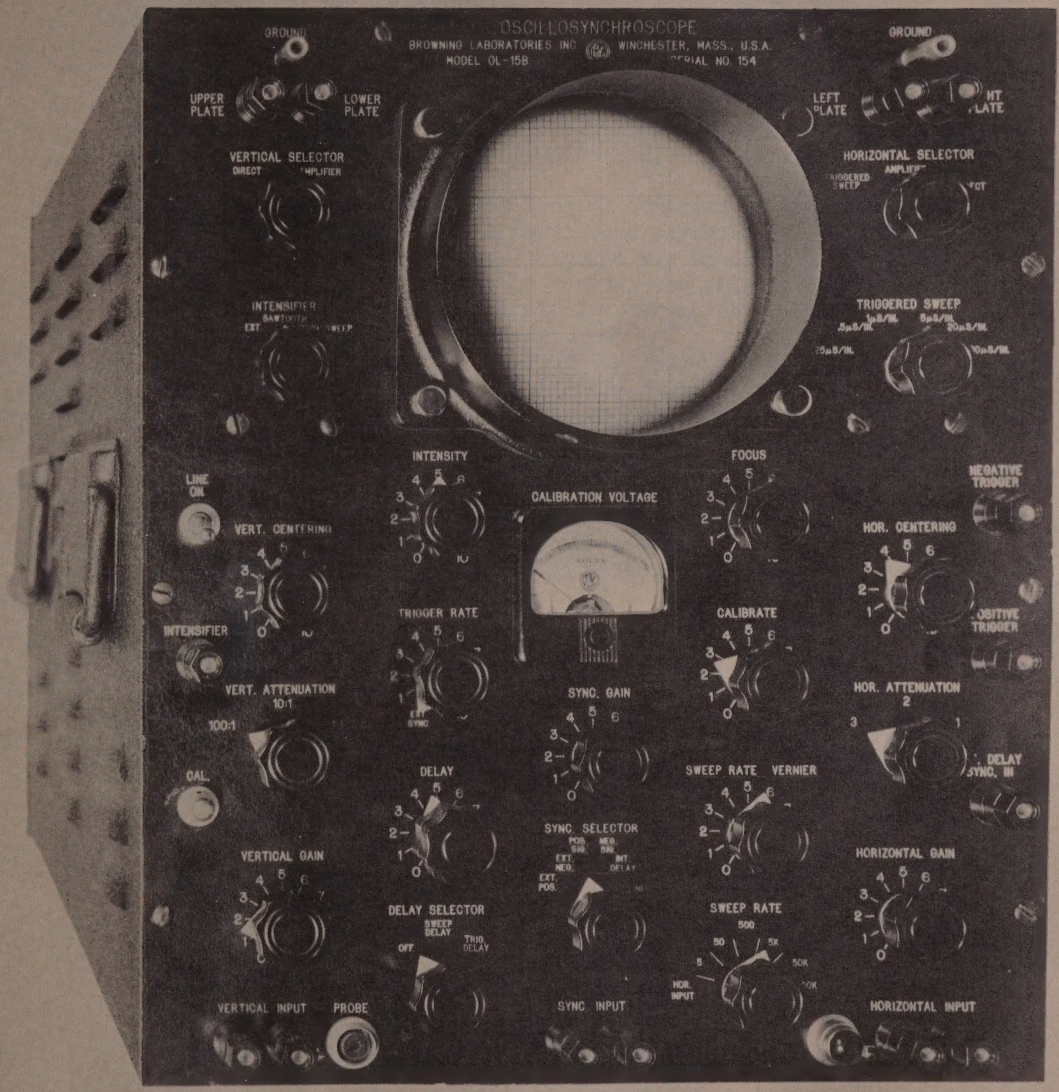
INSTRUCTION MANUAL

for

TYPE OL-15B
OSCILLOSYNCHROSCOPE

BROWNING LABORATORIES, INC.
WINCHESTER, MASS., U.S.A.

TYPE OL-15B
OSCILLOSYNCHROSCOPE


OSCILLOSYNCHROSCOPE
BROWNING LABORATORIES INC WINCHESTER, MASS., U.S.A.
MODEL OL-15B
GROUND
UPPER PLATE
LOWER PLATE
VERTICAL SELECTOR
DIRECT
AMPLIFIER
INTENSIFIER
LINE ON
INTENSITY
VERT. CENTERING
INTENSIFIER
VERT. ATTENUATION
10:1
100:1
CAL.
VERTICAL GAIN
VERTICAL INPUT
PROBE
TRIGGER RATE
DELAY
DELAY SELECTOR
SWEEP DELAY
TRIG. DELAY
OFF
CALIBRATION VOLTAGE
SYNC. GAIN
SYNC SELECTOR
SYNC. INPUT
FOCUS
CALIBRATE
SWEEP RATE VERNIER
SWEEP RATE
500
5K
50K
HOR. INPUT
GROUND
LEFT PLATE
HT PLATE
HORIZONTAL SELECTOR
TRIGGERED SWEEP
NEGATIVE TRIGGER
HOR. CENTERING
POSITIVE TRIGGER
HOR. ATTENUATION
DELAY SYNC. IN
HORIZONTAL GAIN
HORIZONTAL INPUT

I. DESCRIPTION

1. PURPOSE:

The Browning Model OI-15B Oscillosynchroscope is an instrument for giving a visual presentation on a cathode ray tube of phenomena occurring in electrical circuits. It may be used for work on radar, television, counter circuits and other laboratory applications where extremely short pulses or phenomena of irregular occurence rate must be studied. It may also be used for all general laboratory applications or for production testing purposes. The two general classifications of signals that may be studied are:

a. Signals whose duration is long as compared to the time between successive phenomena. A continuous sawtooth type of time base is used for this purpose. Signals may be applied either directly to the deflection plates or through the video amplifier if they are of insufficient amplitude for direct observation.

b. Signals whose duration is short as compared to the time between successive phenomena. A triggered type of sweep is provided for this purpose. Either positive or negative impulses may be used to initiate the sweep. The observed signal itself may be used as a trigger if it is of sufficient amplitude. An internal trigger generator is provided for purposes of initiating actinn in some external equipment if this is desirable. Signal connection here may be to either deflection plates or amplifier depending upon amplitude. A calibrating system is provided for measurement of signal amplitude.

2. CHARACTERISTICS:

a. POWER INPUT: 330 volt-amperes 115 volt, 60 cycle single phase AC.

b. CATHODE RAY TUBE:
   1. Type: 5JP
   2. Deflection sensitivity: 100 volts per inch ± 20%
   3. Input impedance: 2.2 megohms
   4. Maximum input voltage: 600 volts

c. VERTICAL AMPLIFIER:
   1. Maximum deflection sensitivity: .05 RMS volt per inch
   2. Frequency response: Flat within 3 db. from 5 CPS to 6 MC. per second.
   3. Input impedance: 2.2 megohms.
   4. Input impedance with probe: 5 megohms - 10 mmfd.
   5. Attenuation of probe: 10:1.
   6. Maximum input potential: 600 volts.

d. HORIZONTAL AMPLIFIER:
   1. Maximum sensitivity: .05 RMS volt per inch.
   2. Frequency response: Flat within 1 db. from 5 CPS to MC. per second.
   3. Input impedance: 2.2 megohms.
   4. Maximum input potential: 600 volts.

e. SAWTOOTH SWEEP:

1. Frequency range: 5 CPS to 500,000 CPS.
2. Direction: Left to right.
3. Synchronization: The sweep may be made to synchronize on external positive or negative signals of 1.0 volt peak at signal to sweep ratios up to 20:1. It may also be synchronized from video signals which produce at least one-half inch deflection. A sync polarity control is provided for both internal and external sync operation. Synchronization from the power line frequency is also available.

f. TRIGGERED SWEEP:

1. Writing rates of 0.25, 0.5, 1.0, 5, 20 and 200 microseconds per inch.
2. Synchronization: The triggered sweep may be triggered from external positive or negative triggers of 15 to 150 volts peak, from internal video signals of at least one inch deflection, or from the internal delay circuit, or internal trigger generator.

g. TRIGGER GENERATOR:

1. Rate: 200 to 5000 CPS.
2. Amplitude: Positive or negative 60 volts peak.
3. Duration: 2 microseconds.

h. DELAY CIRCUIT:

This circuit provides a continuously variable time delay up to 1000 microseconds. It may be used to delay the triggered sweep with respect to an external positive trigger or with respect to a trigger from the internal trigger generator. It will provide output triggers delayed from the sweep start or output triggers which are delayed from an external sync pulse.

i. CALIBRATION VOLTAGE:

This may be used to check deflection sensitivity through amplifier at any setting of the gain controls.

j. BLANKING:

1. Internal retrace blanking on sawtooth and triggered sweeps is provided.
2. Cathode ray tube grid is brought out to panel connection for external intensity modulation.

k. TUBE COMPLEMENT:

V1	6C4	Video input cathode follower
V2	6AC7	Video amplifier
V3	6AG5	Video amplifier
V4	6AG7	Video phase inverter
V5	807	Deflection amplifier - vertical
V5a	807	Deflection amplifier - vertical
V6	6SN7	Sawtooth sweep charging tube and sync coupler
V7	6SJ7	Sawtooth generator feedback amplifier
V8	6SJ7	Constant current discharge tube - sawtooth generator
V9	6C4	Horizontal amplifier input cathode follower
V10	6AG7	Horizontal amplifier
V11	6AG7	Deflection amplifier - horizontal
V12	6AG7	Deflection amplifier - horizontal
V13	6SN7	Sync amplifier

V14a	6SN7	Sync inverter to sweep gate
V14b	6SN7	Trigger amplifier
V15	6C4	Sweep gate
V16	6SH7	Sweep gate
V17	6SN7	Gate amplifier and clamper
V18	6AG7	Sweep forming pentode
V19	6V6	Sweep inverter
V20	884	Trigger oscillator
V21	6SN7	Delay multivibrator
V22	6SN7	Trigger forming amplifier
V23	2X2A	High voltage rectifier
V24	2X2A	High voltage rectifier
V25	5R4GY	Low voltage rectifier
V26	6V6GT	Series regulator tube
V27	6V6GT	Series regulator tube
V28	6SH7	Voltage regulator amplifier
V29	VR105	Bias regulator
V30	6X5GT	Bias rectifier

l. DIMENSIONS:
19-3/4" x 13-1/8" x 15-3/4"

m. WEIGHT:
90 pounds

3. CONSTRUCTION:
The DL-15B Oscillosynchroscope is contained in a steel case finished in black wrinkle. The front panel is of 1/8" aluminum with black leatherette finish. Louvers are provided in the cabinet for ventilation. The panel and chassis assembly is held in the cabinet by eight #8-32 oval head screws. Four carrying handles are attached to the sides of the cabinet. The chassis is made up of two decks for best electrical efficiency and for ease of servicing. Particular care has been given to the arrangement of the deflection amplifiers for shortest possible leads. All operating controls are on the front panel and have been grouped according to function for convenience of operation. All input and output connections are located on the front panel with the exception of the power cord which plugs into its socket on the rear of the lower chassis.

II. INSTALLATION AND OPERATION

1. INSTALLATION:
Before attempting to operate the equipment make a mechanical inspection to be sure that no damage has incurred in transit. It should not be necessary to remove the unit from the cabinet for inspection. The instrument should be used in a location where there is adequate ventilation to avoid overheating of the unit, and in such a position to avoid as much direct light as possible on the face of the cathode ray tube. The power cord should be plugged into an outlet supplying 115 volt 60 cycle power. If all is in order, the equipment is ready for operation.

2. OPERATION CONTROLS:

a. "LINE ON" Power input switch. Complete circuit from power cord to transformer primaries.

b. "VERTICAL SELECTOR" (S-3) In "AMPLIFIER" position cathode ray tube vertical plates are connected to video amplifier output. In "DIRECT" position the plates are connected to the front panel terminals.

c. "VERT. CENTERING" (R-40, R-41) Controls the positioning of the image in a vertical plane. Clockwise rotation of the control moves the image in an upward direction.

d. "VERT. ATTENUATION" (S-1) Controls the level of signal applied to the input of the video amplifier. Clockwise rotation decreases the amount of attenuation and increases the size of the image on the screen.

e. "VERTICAL GAIN" (R-3) Controls the gain of the video amplifier. Clockwise rotation increases the size of the image on the screen.

f. "INTENSITY" (R-153) Controls the brilliancy of the spot on the screen. Clockwise rotation increases the intensity.

g. "FOCUS" (R-150) Adjusts the focus of the image on the screen.

h. "HORIZONTAL SELECTOR" (S-6) In "TRIGGERED SWEEP" position the horizontal deflection plates are connected to the output of the triggered sweep generator. In the "AMPLIFIER" position the plates are connected to the output of the horizontal amplifier. In the "DIRECT" position the plates are connected to the front panel terminals.

i. "TRIGGERED SWEEP" (S-8) Controls the duration of the triggered sweep. Six positions of 0.25, 0.5, 1, 5, 20, and 200 microseconds per inch are available.

j. "HOR. CENTERING" (R-85, R-86) Controls the positioning of the image in a horizontal plane. Clockwise rotation of the control moves the image to the right.

k. "HOR. ATTENUATION" (S-5) Controls the level of signal applied to the input of the horizontal amplifier.

l. "HORIZONTAL GAIN" (R-66) Controls the gain of the horizontal amplifier. Clockwise rotation increases gain and width of the image.

m. "TRIGGER RATE" (R-120) Adjusts the repetition rate of the trigger impulses. Clockwise rotation increases the rate. In EXT. SYNC. position the trigger oscillator stage becomes a buffer stage between the delay circuit and an external trigger input. Output triggers are then produced at the rate of the incoming sync trigger.

n. "DELAY" (R-127) Controls the duration of the delay multivibrator.

o. "DELAY SELECTOR" (S-10) In "SWEEP DELAY" position the sweep will be delayed with respect to the internal triggers or with respect to an external sync pulse to the delay circuit. In "TRIGGER DELAY" position the output triggers will be delayed with respect to the sweep start or to an external sync pulse to the delay circuit. Delay increases with clockwise rotation of the control, maximum delay being approximately 1000 microseconds.

p. "SWEEP RATE" (S-4) Adjustment of range of control of "SWEEP RATE VERNIER" on sawtooth generator frequency. In "HOR. INPUT" position the sawtooth generator is turned off and the input of the horizontal amplifier connected to the "HORIZONTAL INPUT" jacks.

q. "SWEEP RATE VERNIER" (R-56) Continuous control of sweep frequency. Clockwise rotation increases frequency.

r. "SYNC. SELECTOR" (S-7) Selection of type of synchronizing for sawtooth or triggered sweeps.

s. "SYNC. GAIN" (R-88) Adjustment of amount of synchronizing voltage fed to the sweep generator. Clockwise rotation increases the gain of the amplifier.

t. "CAL." (S-2) Applies calibrating voltage to vertical amplifier.

u. "CALIBRATE" (R-43) Adjustment of calibration voltage. Clockwise rotation increases voltage.

3. OPERATING PRECAUTIONS.

The following precautions should be observed during operation of the oscillosynchroscope:

a. Do not allow the spot to remain in any one position for extended periods of time since the fluorescent coating may be permanently discolored or rendered inactive by the concentrated electron bombardment. The use of the lowest practical intensities is decidedly good practice in oscillographic work for these reasons.

b. Before turning on the equipment make sure of the line voltage and frequency. The transformers are designed for 115 volt 60 cycle operation. While voltage regulators are incorporated in the unit making it possible to operate it over relatively wide ranges of line voltage, it is best to use the instrument between the ranges of 110 to 120 volts input.

c. Do not use the oscillosynchroscope in the vicinity of strong magnetic fields. Such a condition may result in distortion of the beam or permanent magnetization of parts of the instrument.

d. Do not apply DC voltages in excess of 600 volts to any of the input jacks of the equipment. If the oscillosynchroscope must be used on such circuits, an external series condenser of sufficiently high voltage rating must be connected in series with the test lead.

4. OPERATION:

a. OBSERVATION OF REGULARLY RECURRENT PHENOMENA WHERE THE DURATION OF PHENOMENON IS AN APPRECIABLE PART OF THE TIME BETWEEN SUCCESSIVE CYCLES.

1. Use of internal synchronization with sawtooth sweep:

a. Connect signal to be observed to "VERTICAL INPUT" jack or to low capacity cable.

b. Set "VERTICAL SELECTOR" to "AMPLIFIER".

c. Set "INTENSIFIER" to "SAWTOOTH".

d. Set "SYNC. SELECTOR" to POS. SIG. or NEG. SIG. according to the polarity of the signal to be observed.

e. Set "HORIZONTAL SELECTOR" to "AMPLIFIER".

f. Set "HOR. ATTENUATION" to "3".

g. Set "SWEEP RATE" to a position which is closest to the frequency of the signal to be observed.

h. Turn line switch to "LINE ON" and allow approximately one minute for warmup time.

i. Advance "INTENSITY" control until an image appears on the screen.

j. Adjust "FOCUS" for best definition.

k. "VERT. ATTENUATION" and "VERTICAL GAIN" should be adjusted until the image on the screen is about two inches high. If a sufficiently large image cannot be obtained by fully advancing "VERTICAL GAIN", turn "VERT. ATTENUATION" one step in a clockwise direction. If the image cannot be sufficiently reduced, turn "VERT. ATTENUATION" one step in a counterclockwise direction.

l. Adjust "SWEEP RATE VERNIER" and "SYNC. GAIN" for good synchronization. The "SYNC. GAIN" control should be advanced no farther than is necessary for good sync action.

2. Use of external synchronization with sawtooth sweep:
   a. For some types of measurement, it is often more satisfactory to use an external source of synchronizing voltage. For such operation the procedure is the same as Section "4a-1, steps "a" to "n" with the following exceptions:
      1. Instead of "4a-1d", set "SYNC. SELECTOR" to EXT. POS. or EXT. NEG. depending on the polarity of the sync. signal.

      2. Connect external synchronizing voltage to "SYNC. INPUT" terminals.

      3. The setting of the "SYNC. GAIN" control will depend upon the amount of voltage at the "SYNC. INPUT" terminals. At least 0.5 volt of signal must be used for positive synchronization.

3. Use of 60 cycle line synchronization with sawtooth sweep:
This would be the case in measuring power supply ripple or in equipment where the signal is in synchronism with the power supply frequency.
   a. Proceed as in "4A-1a" to "n" with the following exception:
      1. Set "SYNC. SELECTOR" to "LINE".

4. Direct connection to vertical plates:
In some applications it is desirable to eliminate the vertical amplifier and to apply the signal in question directly to the deflection plates of the cathode ray tube. This would be the case where the observed signal contained frequency components beyond the range of the vertical amplifier. The deflection sensitivity of the vertical plates is 100 volts per inch. The amplitude of the signal should be at least this value to provide a satisfactory picture. If it is desired to use the deflection plates directly, proceed as follows:
   a. If the signal is a single-ended one, connect the "LOWER PLATE" terminal to "GROUND" and apply the signal to the "UPPER PLATE" terminal. This will result in an upward deflection for positive signals. With a balanced signal connect one side to "UPPER PLATE" and the other side to "LOWER PLATE".

   b. Set "VERTICAL SELECTOR" to "DIRECT".

   c. Connect some source of voltage which operates in synchronism with the signal to the "SYNC. INPUT" terminals. If no voltage is available other than the signal itself, this may be connected to the "SYNC. INPUT" terminals through a 50 mmfd. condenser. If loading of the signal is unimportant, the condenser may be omitted. Input impedance of "SYNC. INPUT" is 100,000 ohms.

d. Set "SYNC. SELECTOR" to "EXT. POS." or "EXT. NEG." according to the polarity of the sync signal.

e. Set "INTENSIFIER" to "SAWTOOTH".

f. Proceed as in "AA-1e" to "1n" omitting "1k".

b. OBSERVATION OF RECURRENT PHENOMENA WHERE THE DURATION OF THE PHENOMENON IS SHORT WITH RESPECT TO THE TIME BETWEEN SUCCESSIVE PHENOMENA.

1. Where the circuits in question may be triggered:

a. Set "HORIZONTAL SELECTOR" to "TRIGGERED SWEEP".

b. Set "INTENSIFIER" to "TRIG. SWEEP".

c. If circuit under test requires a positive trigger, connect "POSITIVE TRIGGER" terminal to a suitable point in the circuit. If a negative trigger is required, "NEGATIVE TRIGGER" terminal is connected to the appropriate point in the circuit. The trigger voltage at the output terminals is approximately 60 volts.

d. Set "TRIGGERED SWEEP" to 20 microseconds/inch.

e. Set "SYNC. SELECTOR" to "INT. DELAY".

f. Set "TRIGGER RATE" to desired frequency. With the control fully clockwise the frequency is approximately 5000 cycles and approximately 200 cycles in the counter-clockwise position.

g. Turn "INTENSIFIER" to "TRIG. SWEEP".

h. Turn line switch to "LINE ON" and after one minute warmup time, adjust centering and beam controls for best picture.

i. Set "DELAY SELECTOR" to "TRIGGER DELAY". Assuming that the phenomenon under observation occurs at the same time as the triggering pulse, it will then be possible, by means of the "DELAY" control to position the waveform under observation from a point slightly before the sweep to a point approximately 1000 microseconds later. Coarse adjustment may be made by means of the inner knob on the "DELAY" control and a fine adjustment by means of the outer knob on the same control.

If the "DELAY SELECTOR" control is set to the "SWEEP DELAY" position, then the sweep will lag the trigger according to the setting of the "DELAY" control. Under these conditions the observed waveform may be in effect phased back beyond the start of the sweep.

The amount of delay possible can never be more than 90% of the time between the start of successive sweeps or more than 1000 microseconds under any conditions.

j. Advance "SYNC. GAIN" to the point where a stable sweep appears on the screen.

k. With the signal under observation connected to "VERTICAL INPUT", adjust "VERT. ATTENUATION" and "VERTICAL GAIN" for proper image size. (See"4a-1k")

l. If it is desirable to observe the signal directly on the cathode ray tube plates, proceed as in "4a-4a" and "4a-4b".

m. The sweep writing rate may be set to the appropriate point by means of the "TRIGGERED SWEEP" control.

2. Where the external circuits cannot be triggered and must be used to trigger the sweep:

a. Where the external circuits supply a trigger other than the signal to be observed. Proceed as follows:

1. Set "HORIZONTAL SELECTOR" to "TRIGGERED SWEEP".

2. Set "INTENSIFIER" to "TRIG. SWEEP".

3. Set "SYNC. SELECTOR" to "EXT. POS." or "EXT. NEG." depending on the trigger available.

4. Connect external trigger to "SYNC. INPUT" terminals. This should have a value between 15 and 150 volts. The best value is about 30 volts. The trigger voltage selected should occur slightly before the start of the signal for ideal presentation of picture. This position of the image on the screen will depend on the time relation between the signal and trigger and upon the writing rate selected.

b. Where the signal itself is used to trigger the sweep:

1. Set "INTENSIFIER" to "TRIG. SWEEP".

2. Set "SYNC. SELECTOR" to "POS. SIG." or "NEG. SIG." according to the polarity of the incoming signal voltage.

3. Set "VERT. ATTENUATOR" and "VERTICAL GAIN" so that vertical deflection is at least one inch.

4. Set "HORIZONTAL SELECTOR" to "TRIGGERED SWEEP".

5. Select desired sweep speed and advance "SYNC. GAIN" until a sweep appears.

6. Note that some time will be lost in the starting of the sweep so that it will not be possible to observe the first part of the signal. The time lost is approximately 0.2 microseconds.

   If the signal is of sufficient amplitude it is also possible to connect the signal to the "SYNC. INPUT" connectors to trigger the sweep directly without benefit of the internal video connection. This arrangement will load the signal source, of course, with the input impedance of the sync connection. "SYNC. SELECTOR" must be set to either "EXT. POS." or "EXT. NEG." depending on the voltage sign of the waveform.

c. Delayed sweep operation from external trigger:
   1. Set "INTENSIFIER" to "TRIG. SWEEP".

   2. Set "HORIZONTAL SELECTOR" to "TRIGGERED SWEEP".

   3. Connect a positive trigger of at least 30 volts to "INT. DELAY SYNC. IN".

   4. Turn "TRIGGER RATE" to "EXT. SYNC."

   5. "DELAY CONTROL" may be set to produce a sweep which will be delayed from the input trigger by any time up to 1000 microseconds provided that this interval is not greater than 75% of the period between successive triggers.

   6. Set vertical amplifier controls to accommodate the amplitude of the signal in question.

e. USE OF EXTERNAL SWEEP VOLTAGE. FOR CERTAIN MEASUREMENTS AND APPLICATIONS IT MAY BE DESIRABLE TO USE AN EXTERNAL SOURCE OF SWEEP VOLTAGE. THIS MAY BE DONE IN THE FOLLOWING WAYS:

   1. <u>Application of sweep directly to horizontal deflection plates</u>:
      a. Turn "HORIZONTAL SELECTOR" to "DIRECT".

      b. If external sweep is single ended, connect one terminal to "GROUND" and sweep voltage to other terminal. A positive voltage on "LEFT PLATE" will deflect the beam to the left. A positive voltage on "RIGHT PLATE" will deflect the beam to the right. If signal is push-pull connect one side to each plate terminal.

2. Application of sweep through horizontal amplifier:
   a. Turn "HORIZONTAL SELECTOR" to "AMPLIFIER".

   b. Set "SWEEP RATE" to "HOR. INPUT"

   c. Connect sweep voltage to "HOR. INPUT".

   d. Adjust "HOR. ATTENUATOR" and "HORIZONTAL GAIN" for desired sweep length.

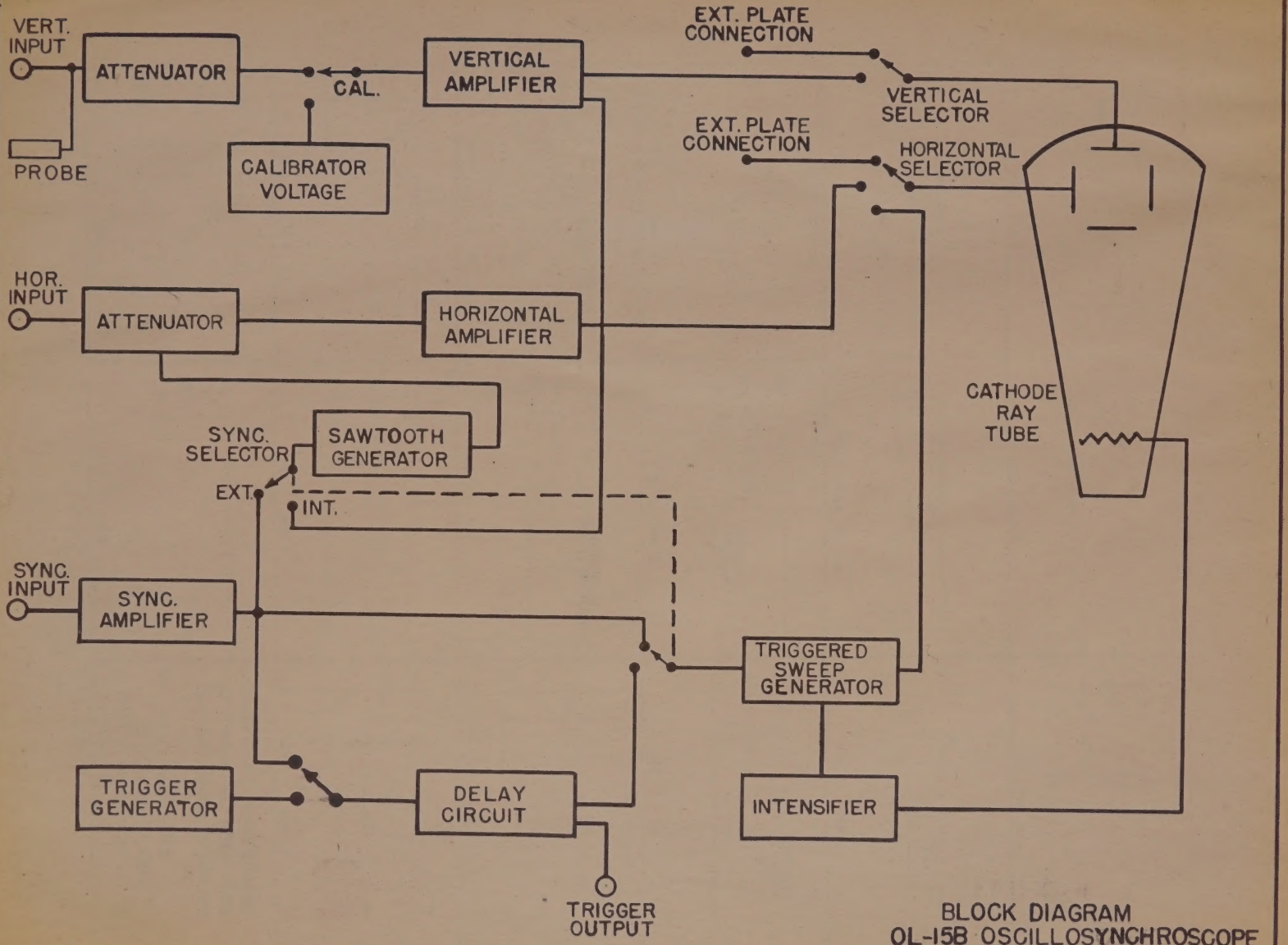
d. MODULATION OF BEAM: The grid of the cathode ray is brought to the connection on the front panel called "INTENSIFIER" when "INTENSIFIER" switch is in "EXT." position. A positive voltage to "INTENSIFIER" connection will increase intensity. A negative voltage will reduce intensity.

e. MEASUREMENT OF SIGNAL INPUT VOLTAGE:
   1. Push "CAL." button on panel.

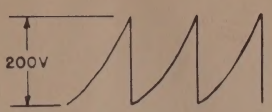
   2. Adjust "CALIBRATE" control until vertical deflection of calibration voltage is the same as the signal under check.

   3. Read meter marked "CALIBRATION VOLTAGE". If "VERT. ATTENUATION" is set to "1" multiply voltage reading by 1; for "10" multiply by 10; for "100" multiply by 100. This value will be equal to the signal at the amplifier input. If the test probe is used, this value must be multiplied by 20.

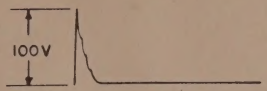
   4. Note that the voltage reading is in peak to peak volts.



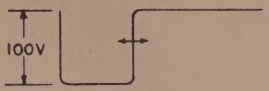
BLOCK DIAGRAM
OL-15B OSCILLOSYNCHROSCOPE



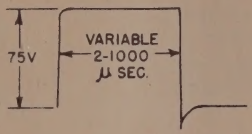
V20 PIN 3



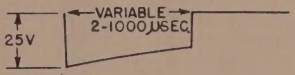
V20 PIN 8



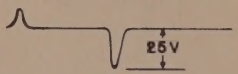
V14 PIN 5



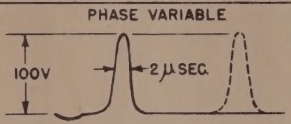
V21 PIN 2



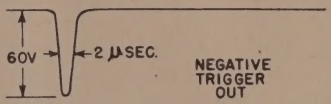
V21 PINS 3 & 6



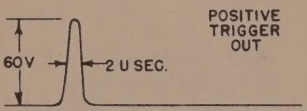
V22 PIN 4



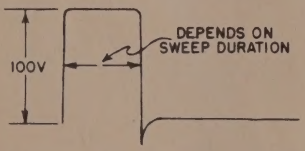
V22 PIN 5



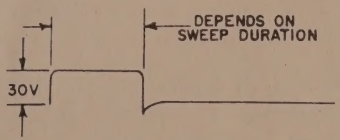
V22 PIN 2



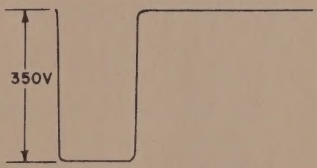
V22 PIN 3



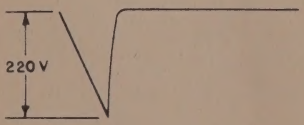
V14 PIN 2



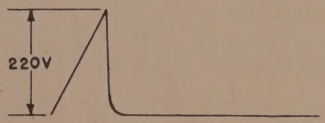
V17 PIN 1



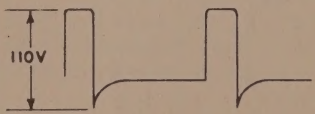
V17 PIN 2



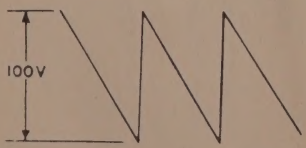
V17 PIN 8



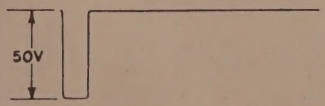
V18 PIN 3



V7 PIN 8



V8 PIN 8



V6 PIN 2

SIGNIFICANT WAVESHAPES APPEARING BETWEEN TUBE PINS AND CHASSIS GROUND

OL—15B
OSCILLOSCOPE

BROWNING LABORATORIES INC
WINCHESTER, MASS. U.S.A.

III. FUNCTIONING OF PARTS

1. CIRCUIT AND DESIGN NOTES:

a. POWER SUPPLY:

The power supply for the CL-15B consists of two electrical sections, the high voltage supply for the cathode ray tube, and the low voltage supply for the amplifier and generators. Two power transformers are employed. One contains all windings requiring high voltage insulation. This includes all windings concerned with the cathode ray tube anode supply. The other transformer contains all remaining heater windings and high voltage for the amplifier power supply. The use of separate transformers simplifies transformer replacement problems.

A voltage from V24, 2000 volts, supplies the cathode of the cathode ray tube and a voltage 2000 volts above ground supplies the third anode of the cathode ray tube. The rectifier for this section is V23.

The low voltage section of the power supply provides regulated voltages of +215 and -105, and unregulated, filtered voltage at +400 volts. Rectifier V25 (5U4G) supplies voltage to filter 76, L17, C76, 77, 78, 79. This voltage supplies an electronic regulator consisting of V26, V27, and V28. A negative supply of -105 volts is provided by V30 and V29. This supply also provides a reference voltage for operation of the electronic regulator for the 215 volt output.

b. CATHODE RAY TUBE:

A 5JP cathode ray tube is used in the CL-15B. The circuit for intensity and focus control is conventional. A second anode voltage control, R148, is provided as an astigmatism adjustment. Push-pull centering is provided by R40, 41 and R85, 86.

Vertical centering voltage is taken from the 215 volt regulated supply. Horizontal centering voltage is supplied from the 400 volt unregulated source through a dropping resistor, to provide additional control in connection with triggered sweep operation.

c. VERTICAL AMPLIFIER:

Input stage of the vertical amplifier is a 6C4 triode cathode follower. Output of the follower is directly coupled to a 6AC7 amplifier through gain control R8. R8 and R9 are returned to ground through C8. With the d.c. isolation provided by C8 voltage on the arm of R8 is constant for any setting of the control. Voltage on the cathode of V2 is slightly higher than that on its grid, providing correct bias for proper operation of V2.

The second amplifier stage uses a 6AC5 pentode (V3) with fixed bias supplied from a divider connected across the negative 105 volt supply. Shunt peaking is used in both V2 and V3. A decoupling network (R12, C10) feeds the plate circuit of V2.

V3 is followed by a 6AG7 phase inverter with 680 ohm plate and cathode load resistances. Proper bias voltage for V4 is provided by returning grid resistor R19 to the junction of R20 and R21. No high frequency compensation is necessary in this stage with the low value of load resistances used.

Push-pull output of V4 supplies driving voltage for deflection amplifiers V5 and V5a (807s). Resistors R28 and R29 suppress any tendency to parasitic oscillation. Shunt and series peaking is used in conjunction with wire-wound non-inductive load resistances. These resistors should be replaced with exact duplicates in the case of failure. With the compensation provided a 6 mc. bandwidth is obtained. Fixed negative bias for the deflection amplifiers is taken from the junction of R24 and R25.

Attention should be given to the input attenuator and voltage calibrator scheme. With "CAL." in the normal position, the input of V1 is connected to one section of S1, ("VERT. ATTENUATOR."). A second section of S1 connects the "VERTICAL INPUT" terminals to the same voltage divider as the grid of V1. In position "100:1" 1/100 of the voltage at the input terminals appears at the grid of V1. In position "10:1" 1/10 of the voltage appears and in position "1:1" the entire voltage is applied to the grid. Capacitors are connected across the divider resistors so that the time constant of the lower half of the divider is equal to the time constant of the upper half. This makes the division of voltage the same over the entire band of frequencies passed by the amplifier. The necessity for a voltage divider arises from the fact that there is a limit to the signal amplitude that can be applied to V2 without overload. Limiting resistor, R9, is such a value that any signal sufficiently large to approach the overload point of V1 will produce an off-screen deflection of the cathode ray tube, so that it will be necessary to select the next attenuator position in order to be able to sufficiently reduce the size of the image on the tube.

In using the voltage calibrating system, "CAL." is depressed and a voltage from the junction of R44 and R45 is impressed on V1 grid in place of the incoming signal. This is adjusted by means of R43 so that the deflection produced by the calibrating signal equals that produced by the signal at the input. Since the calibrating signal is adjusted to produce the same deflection as the incoming signal we know that the calibrating voltage must equal that part of the incoming signal which appears at the grid of V1. Knowing the voltage division of the attenuator, we can multiply the calibration voltage by this factor to obtain the value of the signal at the "VERTICAL INPUT" jack.

The AC Voltmeter called "CALIBRATION VOLTAGE" is an RMS indicating instrument. The values of R44 and R45 have been chosen so that the peak-to-peak voltage across R45 is equal to the RMS value indicated on M1. Thus M1 effectively reads in peak-to-peak volts. The calibrating system used in the OL-15B is accurate only so long as the response of the amplifier is linear.

d. HORIZONTAL AMPLIFIER:

The input system of the horizontal amplifier is identical to that of the vertical amplifier with the exception of the calibration circuit. A 6C4 cathode follower input with gain control in the cathode circuit feeds a 6AG7 which in turn drives push-pull 6AG7's with phase inversion accomplished by cathode coupling. Low frequency compensation is provided in the plate circuit of V10 by R69 and C40. Response of the amplifier is flat within 1 db. from 5 cycles to 1 mc.

e. SAWTOOTH SWEEP GENERATOR:

The sawtooth generator employed in the OL-15B is of the hard tube variety and produces sawtooth waveforms from 5 to 500,000 per second. It is composed of V6, V7, and V8 with feedback action produced by V6 and V7 with V8 serving as a constant current device for supplying a linear change of voltage across the sweep capacitance.

Circuit operation may be best explained by starting from the point at which the sweep capacitance selected by S4A is at maximum voltage. At this point the voltage at the plate of V8 and cathode of V6 (second triode) is about 200 volts. V7 is operated at zero bias and draws a steady state plate current of about 11 ma., resulting in a voltage on its plate and also on the grid of V6 of about 90 volts. V6 will then be in such a state that its grid is negative with respect to the cathode by over 100 volts. Consequently, no plate current flows in this tube. the sweep determining capacitance discharges through V8 at a linear rate determined by the setting of R56, "SWEEP RATE VERNIER" which controls the grid bias on V8. When the sweep capacitance discharges to the point where the voltage on the cathode of V6 is within about 15 volts of the voltage on its grid, plate current begins to flow in V6. This results in the voltage on the plate of V6 changing in a negative direction. This change of voltage is transmitted to the grid of V7 through C22 and R51 resulting in a decrease of plate current in this tube. Voltage at its plate rises and since the plate is directly connected to the grid of V6, the current through the triode increases. This is in addition to the initial increase of plate current through V6. We have then a feedback action which results in V7 being rapidly driven beyond cutoff by the change of voltage on its grid. At the same time V6 conducts heavily and the sweep capacitance begins to charge. The rate of charge is much faster than the discharge of sweep time because of the low impedance of triode V6. The voltage on the plate of V8 continues to rise as the sweep capacitance charges until this voltage, which is also the cathode voltage of V6, becomes more positive than the voltage on its grid with a resulting decrease of plate current in V6. Plate voltage drops at V6 with this change of voltage appearing on the grid of V7 which begins to conduct again, and its plate voltage drops. Feedback action of V6 and V7 returns V7 to its initial zero bias condition and the cycle of operation begins again with the sweep capacitance starting another linear discharge.

A small resistance, R53, and an inductance, L7, is placed in the cathode of V7 for purposes of introducing sync voltage. This same resistance is in common with the cathode of the first triode of V6. A positive voltage change on the grid of the V6 sync triode results in a small positive voltage on the cathode of V7. For external positive sync operation the sync voltage is applied to the grid of V6 through "SYNC. GAIN" control R88. For externa negative voltages V13 serves to invert the signal for proper polarity for application to the sweep circuit.

To obtain synchronization from the vertical amplifier circuits, resistances of 620 ohms are connected in the screen circuits of the 807 deflection amplifiers. There will appear across these resistances a voltage corresponding to the waveform appearing on the screen of the cathode ray tube. Suitable switching is provided (S-7) to utilize this small voltage for synchronization purposes. Sync polarity selection is made possible since voltages of opposite sign appear on the screens.

g. TRIGGERED SWEEP:

The triggered sweep circuits in the OL-15B are built around a single stroke multivibrator consisting of a 6C4 triode and a 6SH7 triode connected. The gate pulse produced by this combination is amplified and inverted by V17, first triode, and fed to a clamper, V17 second triode, and constant current pentode, V18, and inverter V19, to produce a push-pull linear sweep voltage for direct application to the horizontal plates of the cathode ray tube.

For purposes of circuit explanation we may assume that S8 is in position 1, corresponding to the 0.25 microsecond per inch sweep speed condition. C52 and R99 will then be in the circuit associated with V15 and V16. Since the grid return for V16 is to the cathode this tube will conduct readily and sufficient voltage drop will appear across R96 to reduce the plate current in V15 to nearly zero. If a negative impulse should be applied through C51 to the plate of V15, this voltage would be impressed on the grid of V16 through C52 resulting in a decrease of plate current in this tube. The decreasing space current will cause a decreasing voltage to appear across cathode resistor, R96. Since V15 cathode is connected to the cathode of V16 the voltage change results in an effective decrease in grid bias on V15 with increasing plate current. Hence, the plate voltage will drop and this change will in turn be communicated to the grid of V16. We have a feedback condition which will result in the grid of V16 being driven beyond the condition of plate current cutoff. V16 remains in this condition as C52 charges through R99. When the voltage on the grid of V16 reaches a certain point plate current begins to flow again and the voltage across R96 increases. Feedback action rapidly returns the circuit to its stable condition where it remains until another trigger arrives. Thus a negative voltage will be produced at the plate of V15 and a positive voltage pulse at the plate of V16. C52 and R99 are chosen to produce a gate whose duration is as long as the sweep time desired, in this case, 1.25 microsecond (5 inches of deflection at 0.25 microseconds per inch). A portion

of the positive output of V16 is applied to the grid of V17, triode #1, which has been biased to a condition of a very small plate current. As the pulse is applied the tube conducts and a large negative pulse appears at the plate. V17, section 2, is normally conductive so that the sweep capacitance selected by S8C will be charged to a voltage determined by the relative impedances of V17, section 2, and V18. When the negative voltage at the clamp tube (V17 section 2) cuts off current in this tube, the sweep capacitance discharges through V18 at a linear rate. This voltage is applied to the grid of V19 through a compensated attenuator and appears as a positive sweep voltage at the plate of V19. Negative and positive sweep voltages are applied to the horizontal deflection plates of the cathode ray tube. At the same time as the sweep is applied a positive pulse from the sweep gate is impressed on the grid of the cathode ray tube.

With "SYNC. SELECTOR" in "EXT. NEG." position a negative trigger at the "SYNC. INPUT" terminals is passed through R88, "SYNC. GAIN" control to sync amplifier V13. This pulse appears as positive at the plate of V13 and triggers the sweep gate through the sync inverter, V14A.

With "SYNC. SELECTOR" in "EXT. POS." position, a positive trigger at the "SYNC. INPUT" terminals is passed through the "SYNC. GAIN" control to the sync inverter which in turn triggers the sweep gate.

The triggered sweep circuit may also be triggered from the video amplifier as in the case for internal sync with the sawtooth sweep. "SYNC. SELECTOR" will be in either the "POS. SIG." or "NEG. SIG." as the case may be.

h. TRIGGER GENERATOR AND DELAY CIRCUIT:

An 884 thyratron relaxation oscillator serves as the trigger timing source in the CA-15B. A resistor R119 (200 ohms) is in the cathode of this tube (V20). When V20 fires, a sharp voltage pulse is formed across R200. This pulse is inverted by V14B and triggers V21 which operates in a manner similar to that of the sweep gate multivibrator. The width of the delay multivibrator gate is adjustable by means of R127, "DELAY" control. R127 and R127A are a concentric shaft control with R127 (1 meg.) for coarse phasing and R127A (10K) for fine phasing control. With S10 in "SWEEP DELAY" position negative output of the gate is differentiated by the network in the grid circuit of V22. Since V22, triode #1, is at zero bias condition this stage responds only to negative grid excursions, so that a positive trigger voltage appears at the plate of V22, section 1, coincident with the leading edge of the delay gate. At the same time the negative trailing edge of the gate output at the plate of the second triode is applied through C65 to trigger the sweep multivibrator through

the sync amplifier V13. With this arrangement the sweep is delayed with respect to the output triggers. In "TRIGGER DELAY" position the trigger is delayed with respect to the sweep. Since the width of the delay multivibrator cannot be reduced to zero it would normally be impossible to reduce the delay between trigger and sweep to less than about 2.0 microseconds, so that the trigger could not be phased to occur during the two fastest sweep speeds. To overcome this difficulty R123 and C66 are used in the circuit to delay the start of the sweep by about 2.0 microseconds so that the trigger can be phased in to zero time with respect to the sweep start.

When "TRIGGER RATE" is turned to the extreme counterclockwise position, S13 is opened and V20 is heavily biased so that its running rate is very low (around 30 cycles). A positive trigger of at least 30 volts applied to "INT. DELAY SYNC. IN." will trigger the thyratron which in turn will operate the trigger and delay circuits in the same manner as for the free running condition of the trigger generator. Thus the sweep may be effectively delayed with respect to this input trigger when "DELAY SELECTOR" is in "SWEEP DELAY" position. In the "TRIGGER DELAY" position output triggers will be produced which are delayed with respect to the input trigger.

In "OFF" position both trigger generator and delay circuits are inoperative. UNLESS THE TRIGGER GENERATOR OR DELAY CIRCUIT IS IN USE, THIS CONTROL SHOULD ALWAYS BE LEFT IN THE "OFF" POSITION.

IV. MAINTENANCE

1. GENERAL MAINTENANCE:

In all of the following operations make sure that the oscillosynchroscope is completely disconnected from the power source.

a. REMOVAL OF CHASSIS FROM CABINET

To remove the chassis from the cabinet, remove the eight 8-32 oval head screws which hold the panel to the cabinet and the two screws holding the rear of the chassis to the cabinet. Reach through the opening at the lower rear of the cabinet and push the chassis forward until the panel is sufficiently clear of the cabinet to enable one to pull the chassis out by the panel. In pulling the chassis free of the cabinet take care to keep the unit on a level so that those components which are near the top of the unit do not become caught on the cabinet.

b. REPLACEMENT OF CATHODE RAY TUBE

1. Remove chassis from cabinet as described above.

2. Remove all deflection plate and anode connector clips from cathode ray tube.

3. Remove light shield and ruled screen by unscrewing four knurled head bolts holding bezel to panel.

4. Carefully pry cathode ray tube from its socket by means of a screwdriver.

5. Pull cathode ray tube through the hole in the front panel.

6. Follow the reverse of the above procedure to insert a new tube.

7. The locking arrangement for the CR tube socket mounting should be loosened and the socket mount adjusted for the length of the new tube.

c. CHANGE OF RULED SCREEN

The ruled screen covering the end of the cathode ray tube may be removed at any time and a colored or plain screen substituted. To do so remove the four thumb screws from the cathode ray tube light shield bezel. This will permit the bezel to be removed from the panel. The ruled screen is contained in a recess machined in the rear of the bezel. In replacing bezel and screen, care should be taken to see that the lines on the screen are in proper alignment.

d. REPLACEMENT OF MAIN POWER TRANSFORMER

The main power transformer should rarely, if ever, need replacing. In the case that this should become necessary, the following procedure should be followed:

1. Carefully unsolder all leads other than those of the transformer itself which connect to the transformer terminal boards.

2. Remove the four 8-32 screws and nuts which hold the transformer mounting plate to the main chassis crosspieces.

3. Lift the transformer with its mounting plate from the chassis.

4. Disconnect all transformer leads from the transformer terminal boards.

5. Remove the four 1/4-20 nuts and bolts holding the transformer to its mounting plate.

6. Mount a new transformer on the mounting plate and connect transformer leads to terminal boards after cutting to length.

7. Mount new assembly to main chassis and rewire into circuit.

e. REPLACEMENT OF FUSE

A 5 amp. 3AG fuse is located in a holder at the rear of the main chassis. A blown fuse is an indication of an abnormal current drain within the instrument. Resistance checks should be made to determine the source of the difficulty and suitable remedy applied.

f. REPLACEMENT OF COMPONENTS ON FRONT PANEL

If it becomes necessary to replace any of the components on the front panel located between the main chassis and upper deck, these can best be reached by removing the cathode ray tube and working through the opening at the front of the upper deck.

2. CIRCUIT ADJUSTMENT:

a. ADJUSTMENT OF VOLTAGE REGULATOR

The potentiometers for adjusting the 215 volt regulator are located on the rear of the main chassis. To adjust for regulation, proceed as follows:

1. Connect a 0-500 DC voltmeter between ground and the cathodes (pin #8) of V26, and V27.

2. Plug oscillosynchroscope into the output of a Variac.

3. Loosen potentiometer locks and adjust R144 until the voltmeter reads 215 volts.

4. Vary the AC input voltage from 110 to 120 volts and observe the effect on DC voltage output.

5. If the DC output increases with increasing input voltage, turn R145 so that the regulated output decreases slightly.

6. Adjust R144 so that output voltage is 215.

7. Observe effect on changing input voltage on DC output.

8. If output voltage decreases with increasing input voltage, adjust R145 so that DC output increases.

9. Readjust R144 for 215 volts output.

10. Proceed to adjust R144 and R145 in steps until the DC output voltage remains constant at 215 volts for line voltage from 110 volts to 120 volts.

b. ADJUSTMENT OF VERTICAL INPUT ATTENUATOR

When components in or near the input attenuator are replaced it may be found necessary to readjust compensating capacitors C2 and C4 in the vertical amplifier. To adjust vertical attenuator, proceed as follows:

1. Connect a source of 5000 cps square wave to "VERT. INPUT" with "VERT. ATTENUATION" set to 100 and "VERTICAL GAIN" fully clockwise.

2. Set "HOR. SELECTOR" to "AMPLIFIER".

3. Set "SWEEP RATE" to "500-5K" position and "SWEEP RATE VERNIER" to "5".

4. Set "SYNC. SELECTOR" to "INT. POS." or "INT. NEG.".

5. Adjust "SYNC. GAIN" until image is stable on screen.

6. Adjust square wave input for one inch deflection.

7. Adjust "FOCUS" and "INTENSITY" for clear picture and centering controls for center image.

8. If C2 is too high in capacity, the image will have peaks or overshoot on the corners. If C2 is too low in capacity, the corners of the image will be rounded. C2 may be found on the vertical attenuator, the trimmer closest to the chassis. This should be adjusted using an insulated screwdriver until the image is the best looking square wave.

9. Turn "VERT. ATTENUATION" to "10" and adjust C4 in a similar manner. The square input should be readjusted for one inch deflection.

c. ADJUSTMENT OF HORIZONTAL INPUT ATTENUATOR
A similar attenuator is used in the horizontal amplifier. It should be adjusted as follows:

1. Connect a 5000 cps square wave to "HOR. INPUT" terminals and set "HOR. SELECTOR" to "AMPLIFIER".

2. Set "SWEEP RATE" to "HOR. INPUT".

3. Connect a sine wave or sawtooth source of 1000 cps to the "VERT. INPUT" terminals.

4. Set "HOR. ATTENUATION" to "3" and "HORIZONTAL GAIN" to the clockwise extreme.

5. Adjust vertical deflection to 3 inches.

6. Adjust square wave input for a horizontal deflection of one inch.

7. Adjust the frequency of the sine wave input until a stationary pattern is obtained.

8. C33 may now be adjusted in the same manner as for the vertical attenuator.

9. Change "HOR. ATTENUATION" to "2" and adjust C31.

d. ASTIGMATISM ADJUSTMENT
The astigmatism adjustment is located immediately above the cathode ray tube socket. It is best to adjust this control with the triggered sweep in operation. Set the scope into operation using the 5 microsec./in. sweep speed with a signal on the screen of about two inches in height. Set this control to the position which gives equally good focus for both horizontal and vertical deflections when the "FOCUS" control passes through the focus point.

The following measurements were taken with controls set as follows:

HORIZONTAL SELECTOR on AMPLIFIER
HORIZONTAL ATTENUATION on 3
SWEEP RATE on 5K to 50K
SWEEP RATE VERNIER to 5
HORIZONTAL GAIN to give a 3" sweep
DELAY SELECTOR on OFF
FOCUS, INTENSITY, VERT. CENTERING and HOR. CENTERING for normal operation

The setting of the remaining controls is unimportant.

TUBE	PIN 1	PIN 2	PIN 3	PIN 4	PIN 5	PIN 6	PIN 7	PIN 8
V1 6C4	150	NC	Heaters		150	0	6	
V2 6AG7	0	Heater	7½	6	7½	[illegible]	Heater	40
V3 6AG5	-1	0	Heaters		200	150	0	
V4 6AG7	17	Heater	0	15	17	100	Heater	200
V5 807	Heater	210	-10	0	Heater	CAP. - 250V		
V5A 807	Heater	210	-10	0	Heater	CAP. - 250V		
V6 6SN7	60	210	120	0	125	3		
V7 6SJ7	0	Heater	3	3	3	125	Heater	
V8 6SJ7		Heater	0	Approx. -3	0	100	Heater	
V9 6C4	110	NC	Heaters		110	6	8	
V10 6AG7	0	Heater	0	6	7	80	Heater	160
V11 6AG7	26	Heater	0	21	26	215	Heater	220
V12 6AG7	26	Heater	0	21	26	215	Heater	220
V13 6SH7	0	Heater	0.5	0	0.5	100	Heater	190
V23 2X2A	2000			2000	CAP. - 1800 AC			
V24 2X2A	1800 AC			1800 AC	CAP. - 2000 V			
V25 5R4GY		440		550 AC		550 AC		440
V26 6V6GT	0	Heater	390	390	210	NC	Heater	215
V27 6V6GT	0	Heater	390	390	210	NC	Heater	215
V28 6SH7	0	Heater	0	-2	0	225	Heater	210
V29 VR-105		-105			0			
V30 6X5GT			400		400			550 AC

All DC voltages measured to ground with 20,000 ohm/volt meter.
All AC voltages measured with 1,000 ohm/volt meter.

The following measurements should be made with controls set as follows:

HORIZONTAL SELECTOR at TRIGGERED SWEEP
DELAY SELECTOR at SWEEP DELAY
TRIGGER RATE at 5
DELAY at 2
TRIGGERED SWEEP at 0.25 microseconds/in.
SYNC. SELECTOR at INT. DELAY
INTENSIFIER at TRIG. SWEEP
BEAM CONTROLS to produce a normal sweep.

TUBE	PIN 1	PIN 2	PIN 3	PIN 4	PIN 5	PIN 6	PIN 7	PIN 8
V14 - 6SN7	-15	200	0				Heaters	
V14 - 6SN7				-15	210	0	Heaters	
V15 - 6C4	215	NC	Heater		215	0	16	
V16 - 6SH7	0	Heater	15	15	15	150	Heater	150
V17 - 6SN7	-12	260	0	260	400	280	Heaters	
V18 - 6AG7	0	Heater	0	0	3.5	125	Heater	280
V19 - 6V6GT	0	Heater	150	150	0	NC	Heater	6
V20 - 884	0	Heater	200		-7			0.1V
V21 - 6SN7	15	120	15	0	210	15	Heaters	
V22 - 6SN7	0	210	5	0	90	0	Heaters	

V. PARTS LIST

RESISTORS:

R-1	2 meg.	-	1/2 w	-	5%	Continental Carbon
R-2	2 meg.	-	1/2 w	-	5%	Continental Carbon
R-3	220K	-	1/2 w	-	5%	Continental Carbon
R-4	22K	-	1/2 w	-	5%	Continental Carbon
R-5	2.2 meg.	-	1/2 w	-	20%	
R-6	18K	-	1 w	-	20%	
R-7	1.5K	-	1/2 w	-	10%	
R-8	Potentiometer 1K composition					
R-9	75 ohm	-	1/2 w	-	5%	
R-10	1K	-	1/2 w	-	10%	
R-11	1K	-	1/2 w	-	10%	
R-12	27K	-	1 w	-	10%	(30K)
R-13	56K	-	1/2 w	-	10%	
R-14	2.2K	-	1/2 w	-	10%	
R-15	30K	-	1/2 w	-	10%	
R-16	1 meg.	-	1/2 w	-	20%	
R-17	100K	-	1/2 w	-	10%	
R-18	1.2K	-	1/2 w	-	10%	
R-19	1 meg.	-	1/2 w	-	20%	
R-20	68 ohm	-	1/2 w	-	10%	
R-21	620 ohm	-	1/2 w	-	5%	
R-22	680 ohm	-	1/2 w	-	10%	
R-23	24K	-	1 w	-	10%	
R-24	200K	-	1/2 w	-	10%	
R-25	33K	-	1/2 w	-	10%	
R-26	1 meg.	-	1/2 w	-	20%	
R-27	1 meg.	-	1/2 w	-	20%	
R-28	68 ohm	-	1/2 w	-	10%	
R-29	68 ohm	-	1/2 w	-	10%	
R-30	620 ohm	-	1/2 w	-	20%	
R-31	620 ohm	-	1/2 w	-	20%	
R-32	Selected at test					
R-33	Selected at test					
R-34	1.5K	-	10 w	non-inductive		Sprague 10N1T
R-35	1.25K	-	10 w	non-inductive		Sprague 10N1T
R-36	1.25K	-	10 w	non-inductive		Sprague 10N1T
R-37	1.5K	-	10 w	non-inductive		Sprague 10N1T
R-38	2.2 meg.	-	1/2 w	-	20%	
R-39	2.2 meg.	-	1/2 w	-	20%	
R-40	Potentiometer 500K Dual					
R-41	Potentiometer 500K Dual					
R-42	2.2K	-	1/2 w	-	10%	
R-43	Potentiometer 1.5K					
R-44	2K	-	1/2 w			(picked)
R-45	1.1K	-	1/2 w			(picked)
R-46	22K	-	1 w	-	20%	
R-47	2K	-	1/2 w	-	10%	

V. PARTS LIST (CON'T.)

RESISTORS:

R-48	10K	-	1 w	-	10%	
R-49	10K	-	1 w	-	10%	
R-50	100K	-	1/2 w	-	20%	
R-51	1 meg.	-	1/2 w	-	20%	
R-52	1 meg.	-	1/2 w	-	20%	
R-53	130 ohm	-	1/2 w	-	5%	
R-54	30K	-	1 w	-	10%	
R-55	39K	-	1 w	-	10%	
R-56	Potentiometer 50K Carbon					
R-57	2 meg.	-	1/2 w	-	5%	Continental Carbon
R-58	2 meg.	-	1/2 w	-	5%	Continental Carbon
R-59	220K	-	1/2 w	-	5%	Continental Carbon
R-60	22K	-	1/2 w	-	5%	Continental Carbon
R-61	2.2 meg.	-	1/2 w	-	20%	
R-62	4.7 meg.	-	1/2 w	-	20%	
R-63	20K	-	1/2 w	-	10%	
R-64	68K	-	1/2 w	-	10%	
R-65	1.5K	-	1/2 w	-	10%	
R-66	Potentiometer 1.5K					
R-67	220 ohm	-	1/2 w	-	10%	
R-68	18K	-	1 w	-	20%	
R-69	10K	-	1 w	-	10%	
R-70	3K	-	1/2 w	-	5%	
R-71	100K	-	1/2 w	-	10%	
R-72	1.2K	-	1/2 w	-	10%	
R-73	1 meg.	-	1/2 w	-	20%	
R-74	1 meg.	-	1/2 w	-	20%	
R-75	10K	-	1/2 w	-	10%	
R-76	100K	-	1/2 w	-	10%	
R-77	390 ohm	-	2 w	-	10%	
R-78	68 ohm	-	1/2 w	-	10%	
R-78A	68 ohm	-	1/2 w	-	10%	
R-79	10K	-	1/2 w	-	10%	
R-80	10K	-	1/2 w	-	10%	
R-81	6K	-	10 w	non-inductive		Sprague 10N1T
R-82	6K	-	10 w	non-inductive		Sprague 10N1T
R-83	2.2 meg.	-	1/2 w	-	20%	
R-84	2.2 meg.	-	1/2 w	-	20%	
R-85	Potentiometer 500K Dual					
R-86	Potentiometer 500K Dual					
R-87	47K	-	1 w	-	20%	
R-88	Potentiometer 100K					
R-89	5.6K	-	1 w	-	10%	
R-90	68 ohm	-	1/2 w	-	10%	
R-91	56K	-	1/2 w	-	10%	
R-92	1 meg.	-	1/2 w	-	20%	

V. PARTS LIST (CONT.)

RESISTORS:

R-93	27K	-	1/2 w	-	10%	
R-94	150K	-	1/2 w	-	20%	
R-95	22K	-	1/2 w	-	10%	
R-96	1.5K	-	1 w	-	10%	
R-97	2K	-	1 w	-	10%	
R-98	3K	-	2 w	-	10%	
R-99	Selected at test					
R-100	Selected at test					
R-101	Selected at test					
R-102	Selected at test					
R-103	Selected at test					
R-104	Selected at test					
R-105	470K	-	1/2 w	-	20%	(500K)
R-106	100K	-	1/2 w	-	10%	
R-107	20K	-	1/2 w	-	10%	
R-108	470K	-	1/2 w	-	20%	(500K)
R-109	220 ohm	-	1/2 w	-	10%	
R-110	20K	-	1 w	-	10%	
R-111	100K	-	1/2 w	-	10%	
R-112	2.2 meg.	-	1/2 w	-	20%	
R-113	470K	-	1/2 w	-	20%	
R-114	220 ohm	-	1/2 w	-	10%	
R-115	10K	-	10 w			
R-116	510K	-	1/2 w	-	5%	
R-117	51K	-	1/2 w	-	5%	
R-118	100K	-	1/2 w	-	10%	
R-119	200 ohm	-	1/2 w	-	10%	
R-120	Potentiometer 1 meg. with switch					
R-121	20K	-	1 w	-	10%	
R-122	1 meg.	-	1/2 w	-	20%	
R-123	270K	-	1/2 w	-	10%	
R-124	10K	-	1 w	-	10%	
R-125	6.8K	-	1 w	-	10%	
R-126	2.2K	-	1/2 w	-	10%	
R-127	Potentiometer 1 meg.) Dual unit with					
R-127A	Potentiometer 10K) concentric shafts					
R-128	2K	-	1 w	-	10%	
R-129	10K	-	1/2 w	-	20%	
R-129A	10K	-	1/2 w	-	20%	
R-130	10K	-	2 w	-	20%	
R-131	1K	-	1/2 w	-	10%	
R-132	1K	-	1/2 w	-	10%	
R-133	10 meg.	-	1/2 w	-	20%	
R-134	300K	-	1 w			
R-135	2.2 meg.	-	2 w	-	20%	
R-136	2.2 meg.	-	2 w	-	20%	
R-137	100K	-	1 w	-	10%	
R-138	1.5K	-	1/2 w	-	10%	
R-139	150 ohm	-	1/2 w	-	10%	

V. PARTS LIST (CON'T.)

RESISTORS:

R-140	150 ohm	-	1/2 w	-	10%	
R-141	470K	-	1 w	-	20%	
R-142	100K	-	1 w	-	10%	
R-143	100K	-	1 w	-	10%	
R-144	Potentiometer 50K wire wound					
R-145	Potentiometer 50K wire wound					
R-146	1 meg.	-	1/2 w	-	20%	
R-147	1 meg.	-	2 w	-	20%	
R-148	Potentiometer 250K carbon					
R-149	300K	-	2 w	-	10%	
R-149A	300K	-	2 w	-	10%	
R-149B	300K	-	2 w	-	10%	
R-150	Potentiometer 250K carbon					
R-151	300K	-	1 w	-	10%	
R-152	270K	-	1/2 w	-	10%	
R-153	Potentiometer 500K carbon					
R-154	1 meg.	-	1/2 w	-	20%	
R-155	1K	-	10 w			
R-156	10K	-	10 w			
R-157	10K	-	10 w			
R-158	150K	-	1/2 w	-	20%	
R-159	39K	-	1/2 w	-	10%	
R-160	1 ohm	-	1/2 w	-	20%	(1.2 ohm)
R-161	680K	-	1/2 w	-	10%	
R-162	1.5K	-	1/2 w	-	20%	
R-163	200 ohm	-	1/2 w	-	20%	

CAPACITORS:

C-1	0.5 mfd.	-	bathtub	- 600 V
C-2	1.5-7 mmf.	-	ceramic	
C-3	5 mmf.	-	ceramic	
C-3A	20 mmf.	-	mica	
C-4	1.5-7 mmf.	-	ceramic	
C-5	5 mmf.	-	ceramic.	
C-6	100 mmf.	-	mica	- 5%
C-7	620 mmf.	-	mica	- 5%
C-8	500 mfd.	-	electrolytic	- 25V
C-9	20 mfd.	-	electrolytic	- 450V
C-10	20 mfd.	-	electrolytic	- 450V
C-11	500 mfd.	-	electrolytic	- 25V
C-12	20 mfd.	-	electrolytic	- 450V
C-13	0.1 mfd.	-	tubular	- 600V
C-14	20 mfd.	-	electrolytic	- 450V
C-14A	20 mfd.	-	electrolytic	- 450V
C-15	0.1 mfd.	-	molded	- 400V
C-16	8 mfd.	-	elec. tubular	- 150V
C-17	0.1 mfd.	-	tubular	- 600V
C-18	0.1 mfd.	-	tubular	- 600V

V. PARTS LIST (CON'T.)

CAPACITORS:

C-19	0.1 mfd.	-	tubular	- 600V	
C-20	0.1 mfd.	-	tubular	- 600V	
C-21	.01 mfd.	-	tubular	- 600V	
C-22	.01 mfd.	-	tubular	- 600V	or molded paper
C-23	10 mfd.	-	electrolytic	- 450V	
C-24	10 mfd.	-	electrolytic	- 450V	
C-25	1.0 mfd.	-	oil filled	- 600V	
C-26	50 mfd.	-	electrolytic	- 50V	
C-27	2.0 mfd.	-	bathtub	- 600V	
C-28	0.1 mfd.	-	tubular	- 600V	
C-29	.01 mfd.	-	molded	- 600V	
C-30	.001 mfd.	-	mica	- 20%	
C-31	1.5-7 mmf.	-	ceramic	-	
C-32	5 mmf.	-	ceramic		
C-33	1.5-7 mmf.	-	ceramic trimmer	-	
C-34	5 mmf.	-	ceramic		
C-35	100 mmf.	-	silver mica	- 5%	
C-36	620 mmf.	-	silver mica	- 5%	
C-37	.05 mfd.	-	tubular	- 600V	
C-38	20 mfd.	-	electrolytic	- 450V	
C-39	500 mfd.	-	electrolytic	-	
C-40	10 mfd.	-	electrolytic	- 450V	
C-41	10 mfd.	-	electrolytic	- 450V	
C-42	500 mfd.	-	electrolytic	- 25V	
C-43	0.5 mfd.	-	bathtub	- 600V	
C-44	0.5 mfd.	-	bathtub	- 600V	
C-45	0.1 mfd.	-	tubular	- 600V	
C-46	0.1 mfd.	-	tubular	- 600V	
C-47	0.1 mfd.	-	tubular	- 600V	
C-48	25 mmf.	-	mica		
C-49	.01 mfd.	-	molded paper	- 600V	
C-50	1000 mfd.	-	mica	- 20%	
C-51	100 mmf.	-	mica	- 20%	
C-52	25 mmf.	-	silver mica	- 5%	
C-53	500 mmf.	-	silver mica	- 5%	
C-54	2.0 mfd.	-	bathtub	- 600V	
C-55	.01 mfd.	-	molded paper	- 600V	
C-56	Selected at test				
C-57	Selected at test				
C-58	Selected at test				
C-59	Selected at test				
C-60	Selected at test				
C-61	4-30 mmf.	-	mica compression trimmer		
C-62	1000 mmf.	-	mica	- 20%	
C-63	.01 mfd.	-	molded paper	- 600V	
C-64	100 mmf.	-	mica	- 20%	
C-65	25 mmf.	-	mica		

V. PARTS LIST (CON'T.)

CAPACITORS:

C-66	50 mmf.	-	mica	- 20%
C-67	10 mfd.	-	electrolytic	- 450V
C-68	1000 mfd.	-	mica	- 10%
C-69	47 mmf.	-	mica	- 20%
C-70	.01 mfd.	-	molded paper	- 600V
C-71	.01 mfd.	-	tubular	- 600V
C-72	.01 mfd.	-	molded paper	- 600V
C-73	.25 mfd.			- 2000V
C-74	.25 mfd.			- 2000V
C-75	.25 mfd.			- 2000V
C-76	2.0 mfd.	-	bathtub	- 600V
C-77	10 mfd.			- 600V
C-78	10 mfd.			- 600V
C-79	.05 mfd.	-	tubular	- 600V
C-80	.25 mfd.	-	bathtub	- 600V
C-81	.01 mfd.	-	molded paper	- 600V
C-82	20 mfd.	-	electrolytic	- 450V
C-83	0.1 mfd.	-	tubular	- 600V
C-84	0.1 mfd.	-	tubular	- 600V
C-85	.01 mfd.			- 2000V
C-86	.01 mfd.			- 2000V
C-87	0.5 mfd.	-	bathtub	- 600V

TRANSFORMERS:

T-1	high voltage power
T-2	low voltage power
T-3	2.5 volt filament 7500 volt insulation

COILS & CHOKES:

L-1	15 microhy.
L-2	15 microhy.
L-3	Selected at test
L-4	Selected at test
L-5	50 microhy.
L-6	50 microhy.
L-7	50 microhy.
L-8	270 microhy.
L-9	520 microhy.
L-10	470 microhy.
L-11	520 microhy.
L-12	470 microhy.
L-13	100 microhy.
L-14	2.5 millihy.
L-15	270 microhy.
L-16	40 millihy.
L-17	15 henry 250 ma.
L-18	5 henry 80 ma.

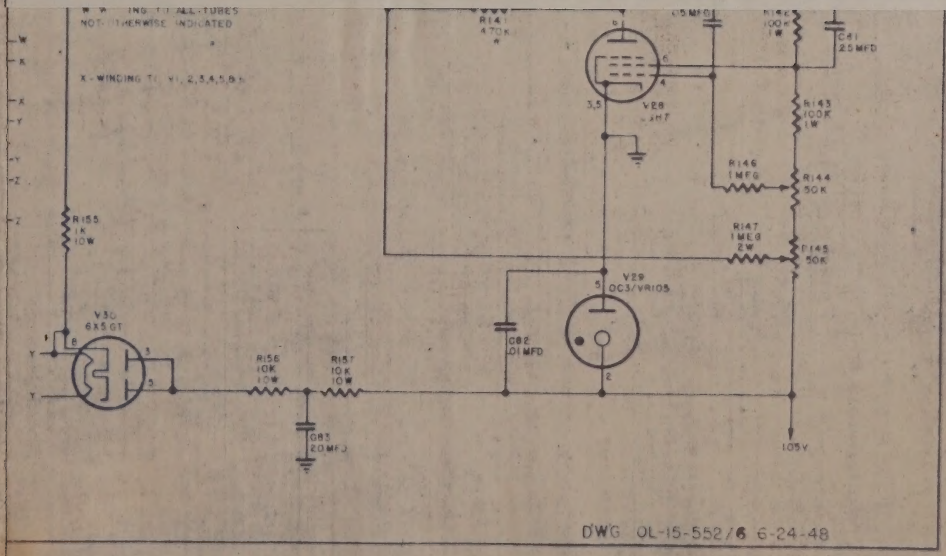
V. PARTS LIST (CON'T.)

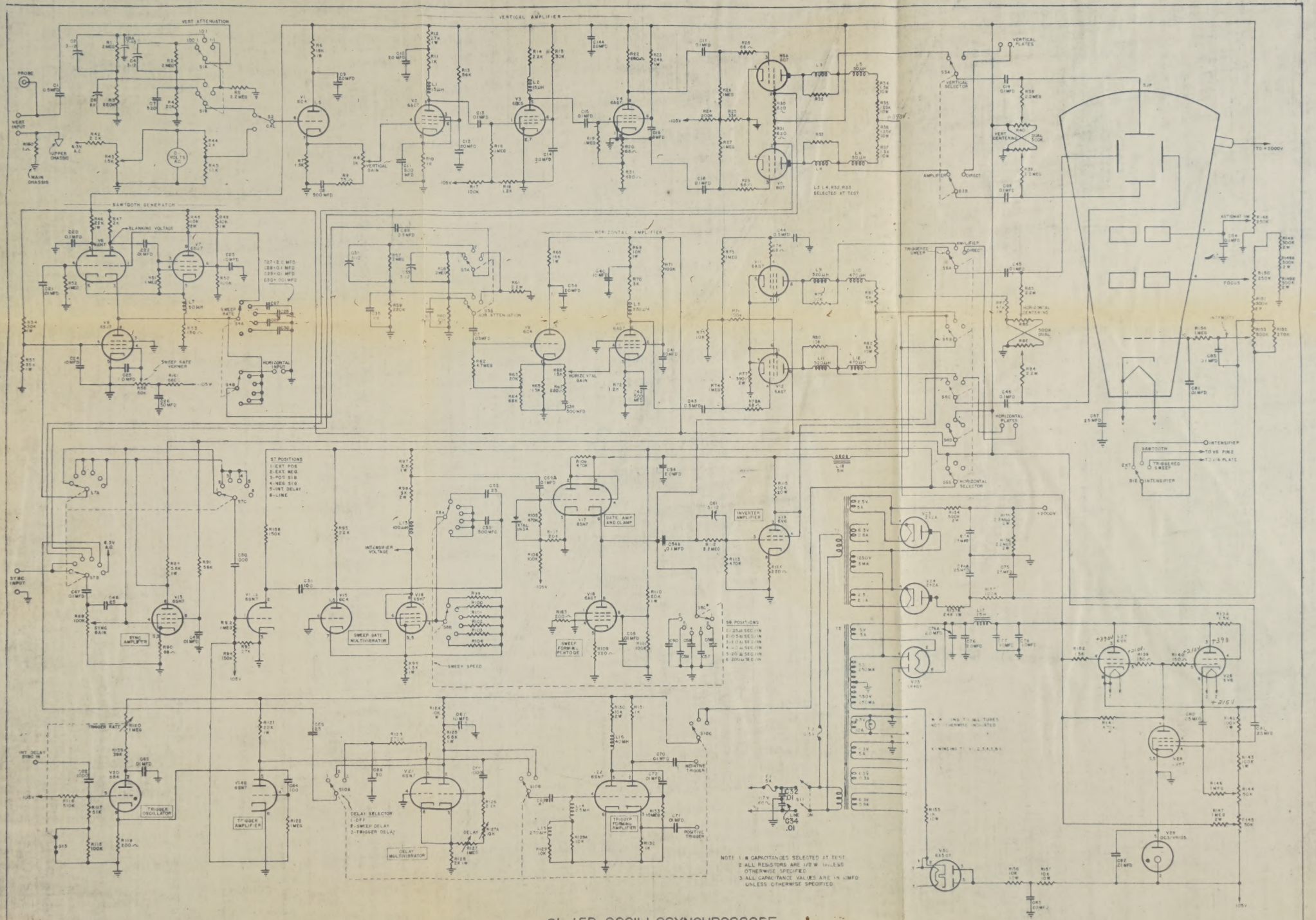
TUBES:

V-1	6C4
V-2	6AC7
V-3	6AG5
V-4	6AG7
V-5	807
V-5A	807
V-6	6SN7
V-7	6SJ7
V-8	6SJ7
V-9	6C4
V-10	6AG7
V-11	6AC7
V-12	6AG7
V-13	6SH7
V-14A	6SN7
V-14B	6SN7
V-15	6C4
V-16	6SH7
V-17	6SN7
V-18	6AG7
V-19	6V6GT
V-20	884
V-21	6SN7
V-22	6SN7
V-23	2X2A
V-24	2X2A
V-25	5R4GY
V-26	6V6GT
V-27	6V6GT
V-28	6SH7
V-29	VR105
V-30	6X5GT

SWITCHES:

S-1	2 circuit 3 pos. rotary switch 60 degree index
S-2	SPDT push button switch, spring return
S-3	2 circuit 2 pos. rotary switch 30 degree or 60 degree index
S-4	2 circuit 6 pos. rotary switch
S-5	2 circuit 3 pos. rotary switch 60 degree index
S-6	5 circuit 3 pos. rotary switch 60 degree index
S-7	3 circuit 6 pos. rotary switch
S-8	3 circuit 6 pos. rotary switch
S-9	3 circuit 4 pos. rotary switch
S-10	3 circuit 4 pos. rotary switch
S-11	DPST toggle switch
S-12	3 circuit 3 pos. rotary switch
S-13	SPST switch on R120

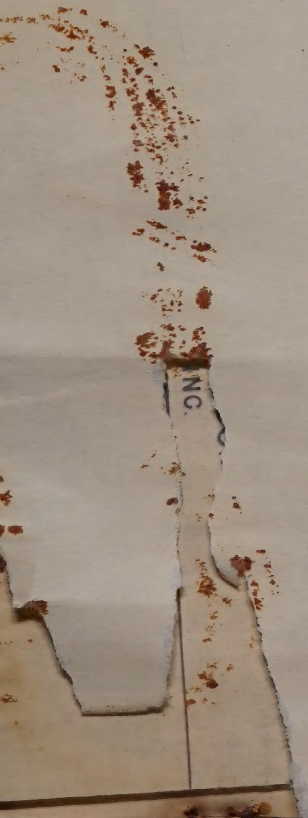

R141
470K
.05MFD
R142
100K
1W
C41
25MFD
V28
6AH7
R143
100K
1W
R146
1MEG
R144
50K
R147
1MEG
2W
R145
50K
V29
OC3/VR105
C82
.01MFD
R155
1A
10W
V30
6X5GT
R156
10K
1W
R157
10K
10W
C83
20MFD
105V
DWG OL-15-552/6 6-24-48



OL-15B OSCILLOSYNCHROSCOPE

BROWNING LABORATORIES, INC.
WINCHESTER, MASS., U.S.A.

DWG OL-15-552/6 6-24-48


INC.